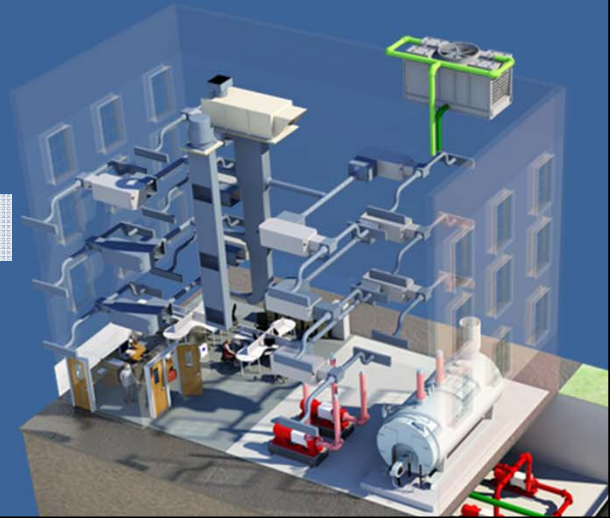




TRACE™ 700

Modeling Ice Storage

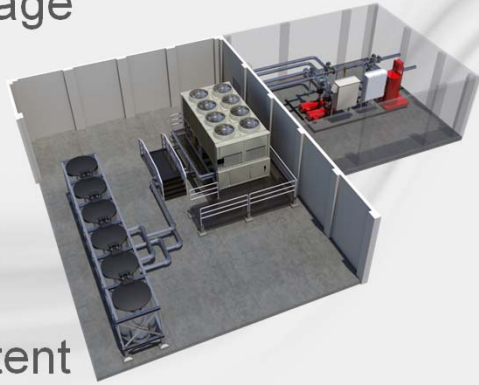


Learning objectives

- Define an ice storage system
- Identify common configurations
- Modeling ice storage
- Outputs and reports

Definition of Ice Storage

- Utilizes thermal energy storage
- Shift the time of chiller operation
 - **Makes ice** during **off-peak** periods
 - **Melts ice** during **on-peak** periods
- Ice storage benefits from latent capacity during phase change



What is ice storage?

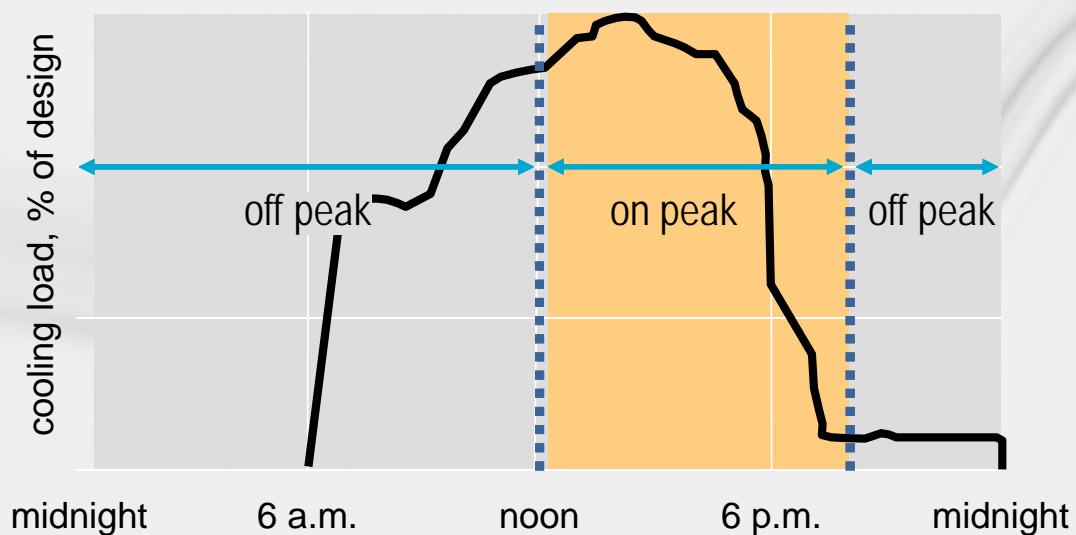


Benefits of Ice Storage

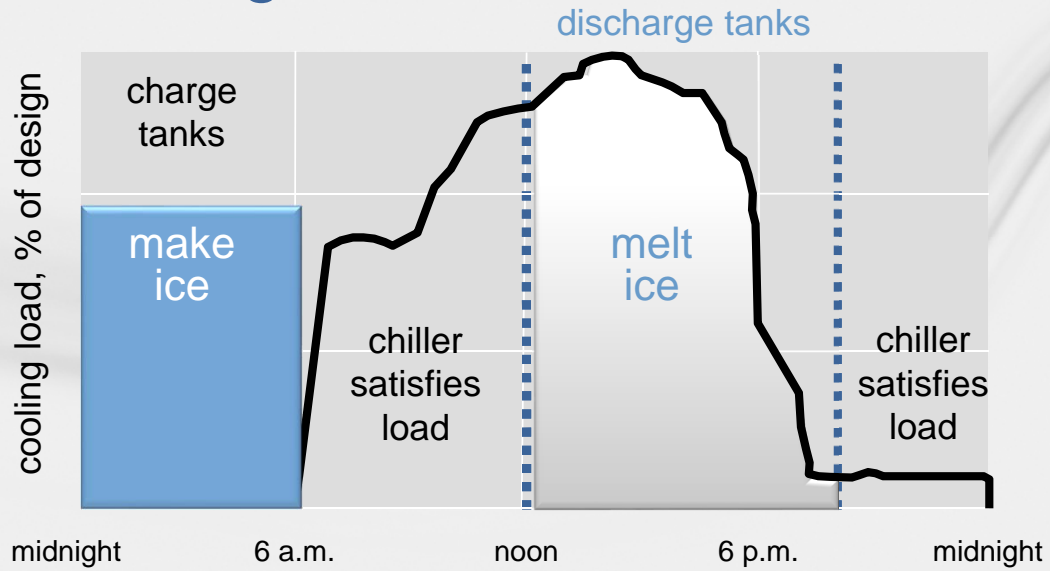
- Lower utility costs
- Smaller equipment size
- Reduced installed cost



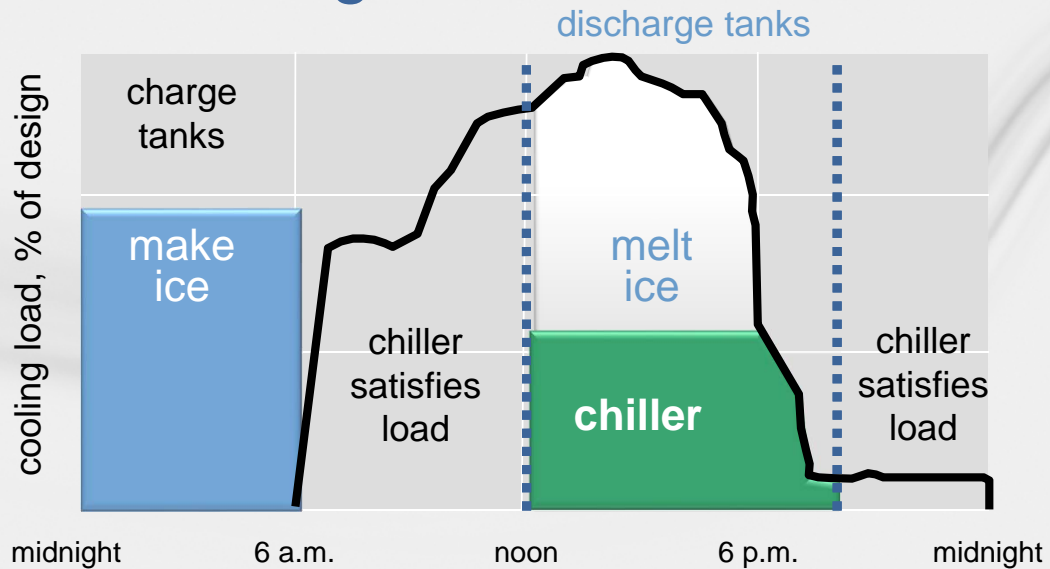
Example Load Profile



Full Storage



Partial Storage



Partial Storage

Design Rules of Thumb

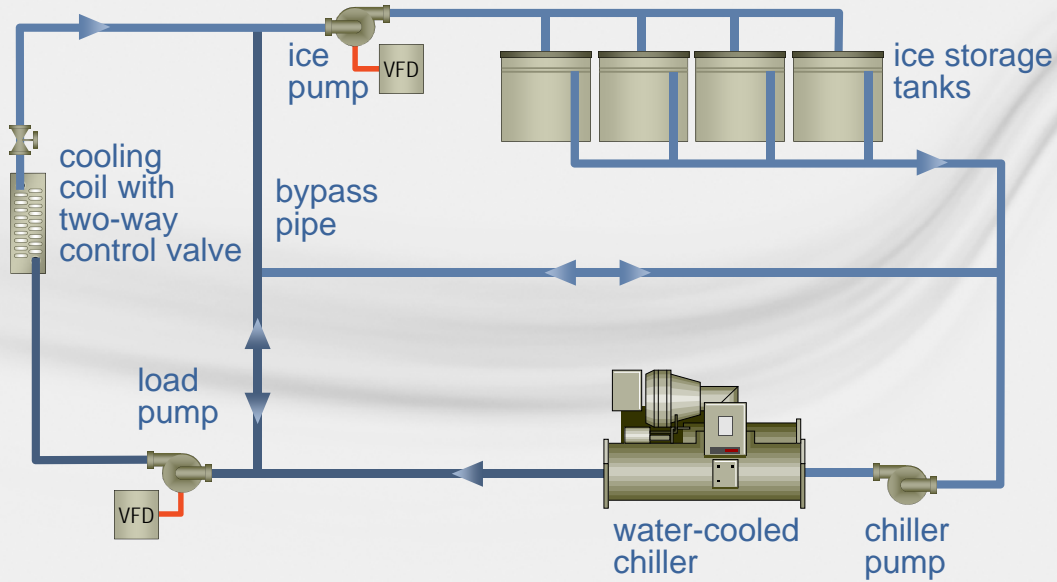
- Ice meets 30% of total design day cooling loads
- Ice discharging rates range from 10 to 30 tons per tank
- Chillers lose 1/3 of capacity during ice building mode
- Ice making time is 8 to 10 hours

TRACE™ 700 Plant Wizard

SCREENCAST

The screenshot displays the TRACE 700 Plant Wizard software interface. The main window is titled 'Create Plants' and shows 'Alternative 1' selected. The 'Equipment Category' pane lists various components such as Air-cooled chiller, Air-cooled unitary, Water-cooled chiller, Water-cooled unitary, Water source heat pump, Boiler, Electric resistance, Gas-fired exchan, Air-cooled condenser, Cooling tower, Pumps, and Therm... storage. The 'Configuration' pane shows a tree structure with 'Cooling plant - 001' selected. A 'Plant Configuration Wizard' dialog box is open, showing a list of chiller configurations and a schematic diagram of an air-cooled chiller ice storage system. The wizard text describes the system as having a chiller upstream of ice tanks and no isolation heat exchanger.

Chiller Downstream of Ice



Chillers Downstream of Ice

Plant Configuration Wizard

Select the desired chiller plant configuration:

- Ded VFF 3 Chillers VFD Twr
- Dedicated VFF 3 Chillers
- Direct Fired Abs. Cooling
- Double Bundle Condenser HR
- Ice Storage - 1 AC Chiller
- Ice Storage - 2 AC Chillers
- Ice Storage - 2 Ice Chillers
- Ice Storage - One Chiller
- Ice Storage - Two Chillers
- Man VFF 2 Chillers Opt Twr
- Man VFF 2 Chillers VFD Twr
- Man VFF 3 Chillers Opt Twr
- Man VFF 3 Chillers VFD Twr
- Manifold VFF 2 Chillers

Ice Storage - 2 Ice Chillers is (2) 500 ton 3-stage centrifugal chillers, each with their own primary chilled water pumps and have a 1000 percent r... The tanks discharge from 7 a.m. to 7 p.m. on the week... remaining time. Standard cooling tower. Constant volum... water pump head, 80 ft. of condenser pump head.

Create Plants

Cooling Equipment - Alternative 1

Cooling plant: Thermal Storage Plant

Equipment tag: Chiller #1

Heat Rejection: Type: Eq5100 - Cooling tower

Hourly ambient wet bulb offset: °F

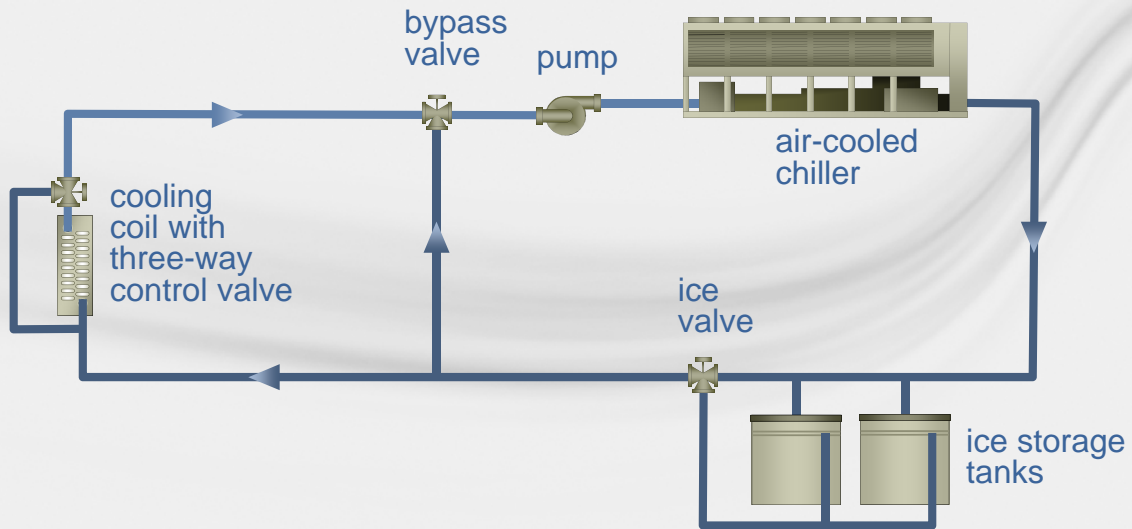
SCREENCAST

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.65 kW/ton
Heat recovery	tons	kW/ton
Tank charging	335 tons	0.78 kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Eq5001 - Crst vol chill water pump	150 ft water
Condenser water	Eq5010 - Crst vol crnd water pump	80 ft water
Heat recovery or aux condenser	None	0 ft water

Configuration Cooling Equipment Heating Equipment Base Utility / Misc. Accessory

Chillers Upstream of Ice



Chillers Upstream of Ice

SCREENCAST

The screenshot shows the 'Plant Configuration Wizard' software. The left sidebar lists various chiller configurations, with 'Ice Storage - 2 AC Chillers' highlighted. The main workspace displays a configuration tree for 'Alternative 1' under 'Cooling plants'. A yellow highlight is placed over the text 'discharge mode charge modes'. The bottom of the window features a tabbed interface with 'Configuration' selected.

Chillers Upstream of Ice

SCREENCAST

The screenshot displays the 'Create Plants' software interface. It features two overlapping windows. The top window is titled 'Create Plants' and shows configuration for a cooling plant. The bottom window is also titled 'Create Plants' and shows configuration for thermal storage. Both windows include dropdown menus for equipment type, sequencing type, and energy source, as well as input fields for capacity and schedule. Below the configuration panels are two tables showing operating modes and pump consumption data.

Operating mode	Capacity	Energy rate
Cooling	75 % Plant Capacity	1.036 kW/ton
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	VV Evap Water Pump - 16 F Delta T	120 ft water
Condenser water	None	0 ft water
Heat recovery or aux condenser	None	0 ft water

Operating mode	Capacity	Energy rate
Cooling	65 % Plant Capacity	1.06 kW/ton
Heat recovery	tons	kW/ton
Tank charging	51 % Plant Capacity	1.324 kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	VV Evap Water Pump - 16 F Delta T	80 ft water
Condenser water	None	0 ft water
Heat recovery or aux condenser	None	0 ft water

SCREENCAST

The screenshot displays the 'Schedule Library' software interface. It features a 'Schedule Definition' panel with dropdown menus for 'Schedule type', 'Month', and 'Day type'. There are also input fields for 'Start' and 'End' dates. Below this is a table for defining schedule periods. The interface includes buttons for 'Save', 'Close', 'New Sched', 'Copy Sched', 'Del Sched', 'New Definition', and 'Copy Definition'. At the bottom, there is a 'Reset and lock-out table' and a note about its application.

Start time	End time	Percentage
Midnight	Midnight	100

%	Sensor type	Op	Reset	Offset	And

NOTE: The reset and lockouts are available for the following: Design phase infiltration, ventilation, reheat minimum, and all system simulation schedules.

Thermal Storage Schedule

The screenshot displays the 'Thermal Storage Schedule' software interface. It features several windows and panels:

- Equipment Configuration:** A window titled 'Cooling Equipment - Alternative 1' with fields for 'Cooling plant' (Cooling plant - 001), 'Equipment tag' (Ice-making Chiller), 'Category' (Water-cooled chiller), 'Equipment type' (3-Stage Centrifugal), 'Sequencing type' (Parallel), 'Energy source', 'Project condenser heat' (Heat rejection equipment), and 'Project heat to plant'.
- Heat Rejection:** A window with 'Type' (Cooling tower for Cent. Chillers) and 'Hourly ambient wet bulb offset'.
- Thermal Storage Table:**

Operating mode	Capacity	Energy
Design	500 tons	0.65 kW
Recovery	tons	kW
Charging	335 tons	0.78 kW
Charging & heat recovery	tons	kW
- Pumps Table:**

Pumps	Type	Full load capacity
Supply chilled water	Const vol chill water pump	150 ft w
Condenser water	Const vol cond water pump - Low Eff	80 ft w
Recovery or aux condenser	None	0 ft w
- Schedule Library:** A window showing 'Schedule Definition' with 'Start' (January) and 'End' (December) months, 'Day type' (Cooling design), and 'Weekday' (Weekday). It includes a table for schedule events:

Start time	End time	Mode
Midnight	7 a.m.	Charge
7 a.m.	11 a.m.	SatNoTank
11 a.m.	5 p.m.	Discharge
5 p.m.	11 p.m.	Satisfy load
11 p.m.	Midnight	Charge

Thermal Storage Library

The screenshot displays the 'Thermal Storage Library' software interface. It features several fields and sections:

- Equipment type:** Climatic
- Comments:** Climate Ice cold Storage Tank 10hrs x 100%design cap.
- Discharge Strategy:** Control type (Optimize), Limit (0 tons).
- Storage:** Capacity, Type (Cooling), Losses (0 Percent), Warning level (0 Percent).
- Fluid Properties:** Specific heat (1 Btu/lb *F), Density (62.32 lb/cu ft), Design delta T (20 *F).

Equipment Level Storage

SCREENCAST

Alternative 1

Thermal Storage Plant

Chiller #1

Water-cooled chiller

Heat Rejection

Type: Eq5100 - Cooling tower

Hourly ambient wet bulb offset: °F

Age: []

Climatic: []

670 [] Percent multiplier

Storage: []

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.65 kW/ton
Heat recovery	tons	kW/ton
Tank charging	335 tons	0.78 kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Eq5001 - Crst vol chill water pump	150 ft water
Condenser water	Eq5010 - Crst vol crnd water pump	80 ft water
Heat recovery or aux condenser	None	0 ft water

Configuration | **Cooling Equipment** | Heating Equipment | Base Utility / Misc. Accessory

Plant Level Storage

SCREENCAST

Alternative 1

Equipment Category

- Air-cooled chiller
- Air-cooled unitary
- Water-cooled chiller
- Water source heat pump
- Boiler
- Electric resistance
- Air-cooled condenser
- Cooling tower
- Pumps

Plant Controls

Description: Cooling plant - 001

Cogeneration type: []

Secondary distribution pump

Type: None

Full load consumption: 0 ft water

Thermal storage

Type: Climatic

Capacity: 670 [] Percent multiplier

Schedule: Storage

TLoop Ent Bldg: None

Flow rate: 100 % of condenser flow rate

Loop pump: None

Pump F.L. rate: 0 ft water

Flow scheme: Fully mixed

Number of simulation years: 1

Loop fluid glycol percent: 0 %

Heat exchanger approach: 0 °F

Configuration | **Cooling Equipment** | Heating Equipment | Base Utility / Misc. Accessory

Equipment Schedule

SCREENCAST

The screenshot shows two windows from a software application. The 'Create Plants' window on the left has the following settings:

- Cooling plant: Cooling plant - 001
- Equipment tag: Ice-making Chiller
- Category: Water-cooled chiller
- Equipment type: 3-Stage Centrifugal
- Sequencing type: Parallel
- Energy source: (blank)
- Reject condenser heat: Heat rejection equipment
- Reject heat to plant: (blank)

The 'Cooling Equipment Controls' window on the right has the following settings:

- Plant description: Cooling plant - 001
- Equipment tag: Ice-making Chiller
- Free Cooling Type: None
- Reset Based On: Chilled Water
- Reset Curve: None
- Max Reset TD: 0 °F
- Equipment schedule: Available for Thermal Storage (highlighted with a red circle)

Outputs: Thermal Storage Report

January - Weekday						
Hour	Typical OADB °F	Typical OAWB °F	Cooling Load ton	Chiller Load ton	Chiller Demand kW	Storage Capacity ton-Hr
1	21.7	20.0	0.0	80.0	48.0	700
2	20.1	18.5	0.0	80.0	48.0	780
3	18.7	17.3	0.0	80.0	48.0	860
4	17.6	16.2	20.0	80.0	48.0	920
5	16.7	15.3	20.0	80.0	48.0	980
6	16.2	14.8	20.0	40.0	24.0	1,000
7	16.0	14.6	40.0	40.0	20.0	1,000
8	16.5	15.5	40.0	40.0	20.0	1,000
9	17.9	16.7	40.0	40.0	20.0	1,000
10	20.1	18.8	60.0	60.0	30.0	1,000
11	22.9	20.9	60.0	60.0	30.0	1,000
12	25.8	23.2	60.0	0.0	0.0	940
13	28.5	25.6	80.0	0.0	0.0	860
14	30.7	27.3	80.0	0.0	0.0	780
15	32.2	28.4	80.0	0.0	0.0	700
16	32.7	28.9	80.0	0.0	0.0	620
17	32.5	29.0	80.0	0.0	0.0	540

charge

satisfy load

discharge

Outputs: Visualizer



Additional resources

- PDF of this presentation
- *TRACE™ 700 User's Manual*
- Online (F1) help
- Trane.com/ContinuingEducation
Ice Storage Design and Application



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